## REMARKS/ARGUMENTS

Claims 1-78 are pending in the application. Claims 10, 40, and 61 are amended herein. The Applicant hereby requests further examination and reconsideration of the application in view of the foregoing amendments and these remarks.

### Claim Rejections and Allowable Subject Matter

In paragraph 2 of the pending office action, the Examiner stated, on page 2, that "Claims 1, 12-24, 31, 42-46, 53, 67, 68 and 71 are rejected under 35 U.S.C. 102(b) as being anticipated by Moorer." In the next-to-last paragraph on page 2, the Examiner referred to "claims 16-18, 46, 51, 52 and 71." The Applicant requests clarification as to whether or not claims 51 and 52 are rejected under 35 U.S.C. 102(b) as being anticipated by Moorer.

In paragraph 4, the Examiner rejected claims 1, 16, 31, 45-46, 51, and 77-78 under 35 U.S.C. 102(e) as being anticipated by Moorer '152. In paragraph 6, the Examiner rejected claims 3 and 32 under 35 U.S.C. 103(a) as being unpatentable over Moorer. In paragraph 7, the Examiner rejected claims 2, 4-5, 14, 25, 33-35, 44, 54-56, and 63-65 under 35 U.S.C. 103(a) as being unpatentable over Moorer in view of Elko. In paragraph 8, the Examiner rejected claims 10-11, 40-41, and 61-62 under 35 U.S.C. 103(a) as being unpatentable over Moorer in view of Elko, and further in view of Staple. In paragraph 9, the Examiner objected to claims 6-9, 36-39, 57-60, 26-30, 47-50, and 72-75 as being dependent upon a rejected base claim, but indicated that those claims would be allowable if rewritten in independent form. For the following reasons, the Applicant submits that all of the now-pending claims are allowable over the cited references.

### The Finality of the Pending Office Action is Improper

In the previous office action dated 02/08/07, the Examiner rejected dependent claims 63-65 under 35 U.S.C. 102(b) as being anticipated by Moorer. In the amendment filed in response to the previous office action, the Applicant did not amend any of claims 63-65. Nor did the Applicant amend either of independent claim 51 or dependent claim 54 from which claims 63-65 depend.

In the pending office action, the Examiner rejected claims 63-65 under 35 U.S.C. 103(a) as being unpatentable over Moorer in view of Elko. This constitutes a new grounds for rejection of claims 63-65. Since the claimed subject matter was not amended, the new grounds for rejecting claims 63-65 makes the finality of the pending office action improper.

In the pending office action, new grounds for rejection were also added for claims 1, 3, 14, 16, 31-32, 44-46, and 51, which were also not amended in the amendment filed in response to the previous office action.

In view of the foregoing, the Applicant requests that the Examiner withdraw the finality of the pending office action.

### The Pending Office Action is Incomplete

In the Office Action Summary (PTOL-326) for the pending office action, the Examiner indicated, at line 6, that claims 66, 69-70, and 76 were rejected. However, the office action contains no discussion or even mention of claims 66, 69-70, and 76. As such, the Applicant has no way of knowing

what the current grounds are for the rejections of claims 66, 69-70, and 76 The Applicant submits therefore that the pending office action is incomplete.

Claims 1, 31, and 51

Claim 1 is directed to a method for processing audio signals. According to claim 1, a plurality of audio signals are received, each audio signal having been generated by a different sensor of a microphone array. The plurality of audio signals is decomposed into a plurality of eigenbeam outputs, wherein each eigenbeam output corresponds to a different eigenbeam for the microphone array and at least one of the eigenbeams has an order of two or greater.

Claim 1 was rejected as being anticipated by both Moorer and Moorer '152.

Moorer

Regarding Moorer, the Examiner stated that Moorer discloses "decomposing the plurality of audio signals into a plurality of eigenbeam outputs ..., wherein each eigenbeam output corresponds to a different eigenbeam for the microphone array and at least one of the eigenbeams has an order of two or greater," citing the end of Moorer's column 5. For the following reasons, the Applicant submits that the Examiner misinterpreted the teachings in Moorer in rejecting claim 1.

Moorer discloses a technique for processing a set of input audio signals in order to generate a desired sound field using a specified configuration of speakers. The technique is illustrated in Figs. 3 and 4. Fig. 3 illustrates the recording portion of the Moorer's overall technique, while Fig. 4 illustrates the playback portion of the overall technique.

In particular, Fig. 3 shows two monaural sources 17 and 19, where each monaural source corresponds to a single audio signal. See, e.g., column 4, lines 30-37. As shown in Fig. 3, the two audio signals are mixed in different combinations (based on a specific five-speaker configuration) to form five recorded signals S1-S5 (see, e.g., column 4, lines 41-60), which are then stored or transmitted for playback using the processing illustrated in Fig. 4. See, e.g., column 6, lines 44-46. According to column 4, lines 37-38, in practice, there are usually far more than two input signals used to make a recording.

Significantly, however, the number of recorded signals (i.e., five in the example of Fig. 3) is a function of the number of speakers in the specific speaker configuration used to generate the recorded signals. See, e.g., column 4, lines 29-30 ("Each of these signals is to drive an individual loud speaker.") Thus, no matter how many input signals are used (i.e., two in the example of Fig. 3 and far more than two in practice), the number of recorded signals is always equal to the number of speakers in the specific speaker configuration used to generate the recorded signals.

Fig. 4 shows the processing used to convert the recorded signals generated in Fig. 3 into speaker signals to be applied to individual speakers to generate the desired sound field. See, e.g., column 7, lines 4-6. This conversion entails two steps: harmonic matrixing 51 and speaker matrixing 53.

In the harmonic matrixing 51 of Fig. 4, the five recorded signals S1-S5 are converted into three spatial harmonic signals: a zero harmonic signal $a_0$ and two first harmonic signals $a_1$ and $b_1$, where the first harmonic signals are orthogonal to each other. See, e.g., column 7, lines 6-10. According to Moorer, harmonic matrixing can be modified such that the five recorded signals S1-S5 can be used to generate spatial harmonics higher than just the zero and first harmonic signals, where two additional

orthogonal signals would be generated by matrix 51 for each further harmonic. See, e.g., column 7, lines 11-13.

In the speaker matrixing 53 of Fig. 4, the three spatial harmonic signals $a_0$, $a_1$, and $b_1$ are combined (based on the actual locations of the five speakers to be used to generate the desired sound field) to generate five speaker signals S1'-S5'. See, e.g., column 7, lines 13-28. Note that these actual speaker locations may differ from those of the specific speaker configuration used in Fig. 3 to generate the recorded signals. In fact, this flexibility in speaker location is the primary advantage provided by Moorer's technique.

According to claim 1, a plurality of audio signals generated by a microphone array are decomposed into a plurality of eigenbeam outputs corresponding to different eigenbeams for the microphone array, where at least one of the eigenbeams has an order of two or greater. In Moorer's Figs. 3 and 4, the only things that could be interpreted as constituting a microphone array are the monaural sources 17 and 19. As described above, the two (or in practice more) input signals from these monaural sources are combined to form recorded signals S1-S5. Since there is <u>no</u> teaching in Moorer that recorded signals S1-S5 are eigenbeam outputs, the processing taught in Fig. 3 <u>cannot</u> be said to constitute an example of a decomposition of a plurality of audio signals generated by a microphone array into a plurality of eigenbeam outputs, let alone eigenbeam outputs corresponding to different eigenbeams for a microphone array, where at least one of the eigenbeams has an order of two or greater.

Moorer teaches that harmonic matrix 51 of Fig. 4 converts the recorded signals into harmonic signals and suggests that the harmonic signals may have order greater than one, but Moorer's recorded signals are <u>not</u> audio signals generated by a microphone array. As such, Moorer's harmonic matrix 51 cannot be said to decompose a plurality of audio signals generated by a microphone array into a plurality of eigenbeam outputs, let alone eigenbeam outputs corresponding to different eigenbeams for a microphone array, where at least one of the eigenbeams has an order of two or greater.

In Figs. 7 and 8, Moorer does in fact teach a technique for decomposing a plurality of audio signals generated by a microphone array into a plurality of eigenbeam outputs. Significantly, however, the decomposition of those audio signals is limited to zero and first harmonics only. In particular, Fig. 8 shows a three-microphone array capable of generating three microphone signals m1-m3, and Fig. 7 shows a technique for combining those three microphone signals m1-m3 to generate three harmonic signals: zero harmonic signal $a_0$ and first harmonic signals $a_1$ and $b_1$. See, e.g., column 9, lines 33-52. There is no teaching or even suggestion of extending the decomposition of Figs. 7 and 9 to harmonic orders greater than first order, let alone describing exactly how such a higher-order decomposition could possibly be achieved.

For all these reasons, the Applicant submits that claim 1 is allowable over Moorer. For similar reasons, the Applicant submits that claims 31 and 51 are allowable over Moorer. Since the rest of the claims depend directly or indirectly from claims 1, 31, or 51, it is further submitted that those claims are also allowable over Moorer.

<u>Moorer '152</u>

Moorer '152 is a CIP of Moorer. The subject matter of Moorer '152 that is not in Moorer is found primarily in Figs. 9 and 10 and columns 12-18. This new subject matter extends the theory of Moorer, which relates to two-dimensional spatial (e.g., planar) harmonics, to three-dimensional spatial (e.g., spherical) harmonics. See, e.g., column 12, lines 1-5. Significantly, the three-dimensional spatial harmonics of Moorer '152 are limited to the $0^{th}$ and $1^{st}$ order terms of the 3-dimensional spatial harmonic

expansion. See, e.g., column 12, lines 5-7 ("It then requires 4 channels to transmit the $0^{th}$ and $1^{st}$ terms of the 3-dimensional spatial harmonic expansion."); column 14, lines 31-32 ("If the $0^{th}$ and $1^{st}$ terms are retained, the rank of [matrix] B will be 4."); column 15, lines 18-20 ("Thus, keeping the harmonics through first order now requires the four terms ($A_0$, $A_1$, $A_{11}$, $B_{11}$) instead of the three terms ($a_0$, $a_1$, $b_1$)."); column 16, lines 29-31 ("A standard directional microphone has a pickup pattern that can be expressed as the $0^{th}$ and $1^{st}$ spatial spherical harmonics."); column 16, lines 47-48 ("With four microphones, we may recover the $0^{th}$ and $1^{st}$ spatial harmonics of the 3D sound field as follows."); column 16, lies 56-57 ("This equation corresponds to the 2D $0^{th}$ and $1^{st}$ spatial harmonics of equation (10)."); column 17, lines 11-13 ("Four microphones unambiguously determine all the coefficients for the $0^{th}$ and $1^{st}$ order terms of the spherical harmonic expansion."); column 18, lines 11-15 ("Any non-degenerate transformation of these four microphone feeds can be used to create any other set of microphone feeds, or can be used to generate speaker feeds for any number of speakers (greater than 4) that can recreate exactly the $0^{th}$ and $1^{st}$ spatial harmonics of the original sound field."); column 18, lines 45-46 ("The matrix, $R_1$, is simply the $0^{th}$ and $1^{st}$ order spherical harmonics evaluated at the speaker positions."); and column 18, lines 65-67 ("For a 2D surround presentation, the inverse of the matrix $\tilde{D}$ is used to derive the 0-th and first 2D spatial harmonics from the first three channels.")

Significantly, as in Moorer, nowhere in Moorer '152 is there a suggestion of decomposing the audio signals generated by a microphone array into eigenbeam outputs where the order of at least one of the eigenbeams is two or greater. The only eigenbeams discussed in Moorer '152 are $0^{th}$ and $1^{st}$ order eigenbeams.

The Applicant cautions the Examiner not to confuse the <u>dimensionality</u> of the spatial harmonics with the <u>order</u> of the terms of the corresponding harmonic expansion. For example, the $0^{th}$ and $1^{st}$ order terms of a spherical harmonic expansion have three <u>dimensions</u>, but their <u>order</u> is less than two.

For all these reasons, the Applicant submits that claim 1 is allowable over Moorer '152. For similar reasons, the Applicant submits that claims 31 and 51 are allowable over Moorer '152. Since the rest of the claims depend directly or indirectly from claims 1, 31, or 51, it is further submitted that those claims are also allowable over Moorer '152.

<u>Claims 10, 40, and 61</u>

According to currently amended claim 10, the microphone array comprises the plurality of sensors mounted on an acoustically soft sphere comprising a gas-filled elastic shell such that impedance to sound propagation through the acoustically soft sphere is less than impedance to sound propagation through liquid medium outside of the sphere. Support for the amendment to claim 10 is found, for example, on page 14, lines 1-8.

In response to the previous rejection of claim 10 based on Staple, the Applicant had previously argued that the Examiner had mischaracterized the subject matter of claim 10 or the teachings of Staple or both in rejecting claim 10 by failing to apply the accepted, conventional definition of the term "acoustically soft sphere" as that term is understood by those of ordinary skill in the art. On page 6 of the pending office action, the Examiner stated that "Applicant's definition of acoustically soft sphere is not a part of the claim." Notwithstanding the fact that the Applicant's definition of an accepted, conventional term of art does not need to be explicitly recited in a claim for that definition to apply, the Applicant has nevertheless amended claim 10 to explicitly recite that definition.

Since Staple and the rest of the cited references do not teach or even suggest the use of an acoustically soft sphere with such a definition, the Applicant submits that this provides additional reasons

for the allowability of claim 10 as well as claims 40 and 61 (and claims 11, 41, and 62, which depend from claims 10, 40, and 61, respectively) over the cited references.

Claims 14, 44, and 65

According to claim 14, the arrangement of the sensors in the microphone array satisfies a discrete orthogonality condition. Note that claim 14 does not state that the eigenbeam outputs generated by the decomposition of claim 1 satisfy a discrete orthogonality condition. That may well be true, but what claim 14 recites is that it is "the arrangement of the sensors in the microphone array" that satisfies a discrete orthogonality condition.

In the present specification, Equation (53) provides an exemplary definition of the discrete orthogonality condition recited in claim 14. As explicitly defined in the specification, the discrete orthogonality condition of Equation (53) is a function of the number ($S$) and positions ($\vartheta_s$, $\varphi_s$) of the sensors in a spherical microphone array. For other (e.g., non-spherical) microphone arrays, the discrete orthogonality condition may be represented in other forms, including, for example, those that take the sensors' radial distances into consideration as well as number and positions of the sensors.

In the first office action, the Examiner rejected claim 14 as being anticipated by Moorer. In response to the first office action, the Applicant argued that Moorer does not teach or even suggest a microphone array whose arrangement of sensors satisfies a discrete orthogonality condition. In the pending office action, the Examiner maintained the rejection of claim 14 as being anticipated by Moorer. In addition, the Examiner included the new grounds of rejection that claim 14 is obvious over the combination of Moorer and Elko.

On page 7 of the pending office action, referring to the Applicant's response to the first office action, the Examiner stated: "On p. 15, applicant argued that Moorer and Elko fails to show the limitation of the arrangement of the sensors in the microphone array satisfying a discrete orthogonality condition as specified in claims 14, 44 and 65."

The Applicant submits that the Examiner mischaracterized the Applicant's argument in the response to the first office action. In particular, the Applicant did not argue that "Moorer and Elko" fail to show the claimed limitation. The Applicant argued only that Moorer fails to show the claimed limitation. The Applicant did not argue that Elko fails to show the claimed limitation, because the Examiner did not rely on Elko in rejecting claim 14 in the first office action. In the pending office action, for the first time, the Examiner now relies on Elko in combination with Moorer to reject claim 14.

In response to the pending rejection of claim 14 as being anticipated by Moorer, the Applicant reasserts the previously filed argument that Moorer does not teach or even suggest the claimed limitation. Significantly, in the pending office action, as in the first office action, in rejecting claim 14 as anticipated by Moorer, the Examiner completely failed to address the claimed limitation. In particular, paragraph 2 of the pending office action does not even mention the discrete orthogonality condition.

In fact, the only reference to the discrete orthogonality condition of claim 14 appears on page 7 of the pending office action, where the Examiner stated that "Elko shows the microphone arrangement satisfying the claimed limitation."

In response, the Applicant admits that the microphone arrangement taught in Elko satisfies the discrete orthogonality condition of Equation (53) of the present patent application. Significantly, however, the microphone arrangement taught in Elko contains four microphones and cannot be used to

generate audio signals that are decomposed into a plurality of eigenbeam outputs where at least one of the eigenbeams has an order of two or greater, as recited in claim 1, from which claim 14 depends. In particular, the four-microphone array of Elko can be used to generate only $0^{th}$ and $1^{st}$ order eigenbeams.

Furthermore, while it is true that Elko's four-microphone configuration satisfies the discrete orthogonality condition of Equation (53), there is no teaching or even suggestion in Elko of any such condition.

As clearly taught in Moorer '152, any four-microphone configuration can be used to generate $0^{th}$ and $1^{st}$ order eigenbeams as long as no two microphones point in the same direction and the four microphones are non-coplanar. See, e.g., column 17, lines 11-16. In fact, there are an infinite number of four-microphone configurations that satisfy Moorer' conditions and can therefore be used to generate $0^{th}$ and $1^{st}$ order eigenbeams. Significantly, however, only a small subset of the four-microphone configurations that satisfy Moorer's conditions will also satisfy the discrete orthogonality condition of Equation (53).

Just because Elko's four-microphone configuration for $0^{th}$ and $1^{st}$ order decomposition happens to satisfy the discrete orthogonality condition of Equation (53) that does not constitute a recognition of such a discrete orthogonality condition for higher-order decompositions.

Table 7 on page 30 of the present application identifies the locations of microphones in a 4-element spherical array that corresponds to the four-microphone configuration in Elko. Meanwhile, Tables 4, 5, and 6 identify the locations of microphones in 20-element, 24-element, and 6-element spherical arrays, respectively. The microphones in each of these four different spherical arrays satisfy the discrete orthogonality condition of Equation (53). The array represented in Table 7 is limited to $0^{th}$ and $1^{st}$ order eigenbeams, while each of the arrays represented in Tables 4, 5, and 6 can be used to generate at least one eigenbeam of at least order two, in addition to $0^{th}$ and $1^{st}$ order eigenbeams.

Without a recognition of a general geometric principle such as the discrete orthogonality condition, it is not obvious how to extend the 4-element geometry of Table 7 to the greater-element geometries of Table 4, 5, and even 6.

As in the case of four-microphone configurations described in Moorer, where an infinite number of 4-element geometries can be used to generate $0^{th}$ and $1^{st}$ order eigenbeams that do not satisfy the discrete orthogonality condition of Equation (53), there are an infinite number of greater-element geometries that can be used to generate eigenbeams of order two or greater that do not satisfy the discrete orthogonality condition of Equation (53).

In general, a generic suggestion of second and higher order eigenbeams does not constitute the teaching or even suggestion of a discrete orthogonality condition, such as that expressed in Equation (53).

For all these reasons, the Applicant submits that the combination of the teachings in Moorer with the four-microphone, "lower-than-second order" configuration of Elko does not teach or even suggest the discrete orthogonality condition of claim 14 as applied to the second order or higher microphone configurations of claim 1.

As such, the Applicant submits that this provides additional reasons for the allowability of claim 14 as well as claims 44 and 65 over Moorer.

Claims 15 and 66

According to claim 15, decomposing the plurality of audio signals further comprises treating each sensor signal as a directional beam for relatively high frequency components in the audio signals. In rejecting claim 15, the Examiner stated that "Moorer shows the step of treating each sensor signal as a direction beam," citing column 7, lines 60-65. For the following reasons, the Applicant submits that the Examiner mischaracterized the teachings of Moorer in rejecting claim 15.

In column 7, lines 60-65, Moorer states:

> "Thus, in the representation of this algorithm shown as the matrix 51, the amplifiers 63, 67, 70, 73 and 76 have unity gain, the amplifiers 64, 68, 71, 74 and 77 have gains less than one that are cosine functions of the assumed speaker angles, and amplifiers 65, 69, 72, 75 and 78 have gains less than one that are sine functions of the assumed speaker angles."

The Applicant does not understand how these teachings in Moorer are in any way related to the feature explicitly recited in claim 15 that "decomposing the plurality of audio signals further comprises treating each sensor signal as a directional beam for relatively high frequency components in the audio signals." For example, the cited teachings in Moorer do not appear to have anything to do with high frequency components of audio signals. Nor do those teachings appear to have anything to do with treating each sensor signal as a directional beam.

As such, the Applicant submits that this provides additional reasons for the allowability of claim 15 as well as claim 66 over Moorer.

Claims 23 and 53

According to claim 23, an equalizer filter is applied to each eigenbeam output to compensate for frequency dependence of the corresponding eigenbeam. In rejecting claim 23, the Examiner stated that "Moorer shows the equalizer filter," citing column 6, lines 19-42. In response, the Applicant submits that the Examiner mischaracterized the teachings of Moorer in rejecting claim 23.

In column 6, Moorer describes the application of scalar weights. Such processing is not even filtering, let alone equalizer filtering. In fact, the terms "equalizer" and "filter" and their derivatives do not even appear in Moorer. As such, the Applicant submits that this provides additional reasons for the allowability of claim 23 and also claim 53 over Moorer.

Claim 45

According to claim 45, a processor is configured to decompose a plurality of audio signals generated by the sensors into a plurality of eigenbeam outputs, wherein each eigenbeam output corresponds to a different eigenbeam for the microphone array and at least one of the eigenbeams has an order of two or greater. The Examiner rejected claim 45 as being anticipated by both Moorer and Moorer '152.

As described previously in the context of claims 1, 31, and 51, neither Moorer nor Moorer '152 teaches or even suggests the decomposition of audio signals generated by a microphone array into eigenbeam outputs where the order of at least one of the eigenbeams is two or greater. The only eigenbeams discussed in Moorer '152 are $0^{th}$ and $1^{st}$ order eigenbeams.

The Applicant submits that this provides additional reasons for the allowability of claim 45 over the cited references.

Claims 77-78

According to claim 46, an auditory scene is generated based on the eigenbeam outputs and their corresponding eigenbeams. According to claim 77, which depends from claim 46, the auditory scene is a second-order or higher directional beam steered in a specified direction, and the auditory scene is generated by (1) receiving the specified direction for the directional beam and (2) generating the directional beam by combining the eigenbeam outputs based on the specified direction.

In rejecting claims 77-78, the Examiner cited Moorer '152, stating: "The claimed auditory scene reads on the audio signal reproduced by a speaker." As described previously in the context of claims 1, 31, and 51, the auditory scene taught in Moorer '152 is limited to those generated using $0^{th}$ and $1^{st}$ order eigenbeams. See, e.g., column 18, lines 11-15 ("Any non-degenerate transformation of these four microphone feeds can be used to create any other set of microphone feeds, or can be used to generate speaker feeds for any number of speakers (greater than 4) that can recreate exactly the $0^{th}$ and $1^{st}$ spatial harmonics of the original sound field.") There is simply no teaching or even suggestion in Moorer '152 of an auditory scene that is "a <u>second-order or higher</u> directional beam steered in a specified direction," as explicitly recited in claim 77.

As such, the Applicant submits that this provides additional reasons for the allowability of claim 77 as well as claim 78 over the cited references. The same argument applies to claim 76.

For the reasons set forth above, the Applicant respectfully submits that the rejections of claims under Sections 102(b) and 103(a) have been overcome.

In view of the above amendments and remarks, the Applicant believes that the now-pending claims are in condition for allowance. Therefore, the Applicant believes that the entire application is now in condition for allowance, and early and favorable action is respectfully solicited.

Respectfully submitted,

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